

Lemon Rootstock Trials in Arizona – 2008-09 and 2009-10¹

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Abstract

In a rootstock evaluation trial planted in 1993, five rootstocks, 'Carrizo' citrange, Citrus macrophylla, 'Rough Lemon', Swingle citrumelo and Citrus volkameriana were selected for evaluation using 'Limoneira 8A Lisbon' as the scion. 1994-2006 yield and packout results indicate

Introduction

There is no disputing the importance of citrus rootstocks to desert citrus production. The ideal citrus rootstock must be compatible with the scion, be adaptable to the appropriate soil and climactic factors and should also improve one or more of the following characteristics: pest and disease resistance, cold tolerance, precocity, internal and external fruit quality, yield and/or post-harvest quality. Ultimately, the value of a rootstock lies in its ability to improve production and/or quality of the fruit.

Climactic and soil characteristics of the desert citrus growing regions impose stress upon a citrus tree. Many times, rootstocks that are suitable for other areas are not suitable in the desert because of climate and soil conditions. Conversely, rootstocks that may be of limited value in other citrus growing areas might be more useful under desert conditions. It cannot be assumed that rootstocks will perform similarly across all climactic and soil conditions.

This first rootstock trial that we planted in 1993 was established to fill a large knowledge gap as to which were the appropriate lemon rootstocks for the Arizona industry. This trial includes rough lemon (*C. jambhiri*), a vigorous and formerly popular rootstock that is no longer as popular since it is susceptible to *Phytophthora* root rot, particularly in the nursery. Also included is *C. macrophylla*, also popular, but susceptible to brown wood rot (*Coniophora eremophila*. and *Antrodia spp.*) and Macrophylla decline. Also included are *C. volkameriana*, a popular but untested rootstock, as well as 'Carrizo' citrange and 'Swingle' citrumelo as experimental rootstocks for the desert ('Carrizo' is commonly used as a rootstock for lemon in coastal California, while 'Swingle' is found in the same areas of California as well as in Florida, but seldom as a rootstock for lemons). 'Limoneira 8A Lisbon' lemon is the scion. Data collected from these trials has included tree growth, mineral nutrition, fruit quality, fruit size and total yield. Previous results from this trial have been reported annually; most reports are available at <http://www.ag.arizona.edu/pubs/> once the word "citrus" is entered into the search box. Previous reports can also be found at <http://www.azda.gov/CDP/CitrusPfprojects.htm> . The 2009-2010 harvest year is the final year for this project.

Materials and Methods

This trial was established in March 1993 in Block 26 of the Yuma Mesa Agricultural Center, near Yuma, Arizona. The land was laser leveled and fumigated prior to planting. Trees were planted on a 10-m x 10-m spacing. Ten

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replicates of each of the 5 rootstocks were planted for a total of 50 trees. Experimental design is randomized complete block.

Irrigation is border flood, and normal cultural practices are used. Yield data is typically collected during the fall and winter. For the 2008-09 season, trees were picked by commercial pickers twice during the season, on 10-14-08 and 1-30-09, and for the 2009-10 harvest season, trees were picked on 10-19-09 and 1-15-10. Only harvestable yield is collected from the trees; some fruit remain on the trees that are judged by the packinghouse to be commercially unsalable. Total harvestable yield is measured by counting the number of whole and fractional 65-lb. picking sacks harvested from each tree. About 35 lbs of fruit is collected from each tree, and passed through an automated electronic eye sorter (Autoline, Inc., Reedley, CA), which provides individual fruit weight, color, exterior quality and size data for each fruit. Fruit packout data is reported on a percentage basis. Only first harvest packout was collected for these two seasons.

All data is analyzed using SPSS 8.0 for Windows (SPSS Inc., Chicago, Illinois).

Results

For 2008-09 and 2009-10, trees on *Citrus macrophylla*, *Citrus volkameriana* and Rough Lemon rootstocks had similar or greater yields than those on 'Carrizo' citrange and 'Swingle' citrumelo (Figure 1). This continues a trend that has been apparent since the 1996-97 season. Compared to 2007-08, yields for trees on all the rootstocks tested decreased by as much as 50%. While the extreme alternate bearing that occurred from 2005-06 to 2007-08 has moderated, the yields for the three top-performing rootstocks are as low as they have been since 2000-01. It is unclear why this is the case, since insect and disease pressures do not appear to be adversely affecting the trees. It is possible that nematode populations are increasing, leading to root feeding and reduced tree vigor. Yields for 'Carrizo' and 'Swingle' are typically lower than the others, but the difference in yields between these two rootstocks and the other cultivars are more narrow than usual.

Considering only the yield from the 2008-09 year, there was no effect of rootstock upon total yield (Figure 2). This is an atypical result, only in the 2006-07 season has there been no effect of rootstock on yield. For the 2009-10 season (Figure 3), the results are more typical, where the yields of *C. macrophylla*, *C. volkameriana*, and Rough Lemon are superior to those of 'Carrizo' and 'Swingle'. These results are similar to our findings for every year since 1998, (with the exception of the 2006-07 season). However, the differences between the upper three and the lower two are narrow, and are not always statistically significant. For the 10-19 harvest, only yields of *C. macrophylla* were statistically greater than the other rootstocks tested. For the 1-15 harvest, the results were similar, with yields of *C. macrophylla* being statistically greater, and yields of 'Swingle' being statistically less than yields of the others.

Packout for the 10-14-08 harvest is shown in Figure 4. Trees on *C. macrophylla*, and *C. volkameriana* and rough lemon had significantly more fruit of sizes 95 than trees on 'Carrizo', while trees on Rough Lemon and 'Swingle' were intermediate. There were no significant effects of rootstock on fruit of size 75, or 115 or smaller. For the 10-19-09 harvest trees, there was no effect of rootstock upon packout.

For 2008-09 and 2009-10, rootstock had no effect upon fruit grade, color or shape.

Discussion and Conclusions

It is apparent that all rootstocks other than *C. macrophylla*, *C. volkameriana* and 'Rough Lemon' are unsuitable as rootstocks for lemon in Arizona in high pH soils. Reduced yield, late fruit sizing and ultimate small fruit size in most years are characteristics that have not been overcome.

Differences between *C. volkameriana* and *C. macrophylla* had been becoming increasingly clear. From 1997-98 until 2003-04, yield of trees on *C. macrophylla* has equaled or surpassed the yield of trees on *C. volkameriana*.

However, for five of the past six seasons, yields of trees on these two rootstocks were virtually the same. However, in 2009-10, yields for *C. volkameriana* were again less than yields for *C. macrophylla*. There is no clear trend as to which of these rootstocks produces earlier fruit, and overall fruit size appears to be similar. Arizona packinghouse managers report that fruit of trees on *C. macrophylla* have a smoother peel, which leads to better overall fruit quality. Growers also report that *C. volkameriana* produces more water sprouts on the trunk than does *C. macrophylla*, and that trees on *C. volkameriana* show more transient nutrient deficiencies in the winter (winter yellows), than do trees on *C. macrophylla*. Perhaps an altered fertilizer regime with more fall micronutrient application would improve the yield of *C. volkameriana* trees. In light of the January 2007 freeze, it is also notable that some producers report that trees on *C. volkameriana* appear to be more cold-hardy. Most growers in the region have the majority of their trees on *C. macrophylla* rootstock, and this study would certainly support that rootstock/scion combination.

After a slow start, 'Rough Lemon' has not had significantly different yield than *C. volkameriana* for the past eight years. 'Rough Lemon' has not typically produced as well as *C. macrophylla*, but for the first time in 2004-05, it had the greatest yield. This was repeated in 2007-08 and 2008-09, but not in 2005-06, 2006-07 or 2009-10. When there is more than one harvest per season, 'Rough lemon' sometimes produces less early-season fruit compared to the other two vigorous rootstocks tested, although this was not the case in 2007-08. 'Rough Lemon' is more difficult to grow in the nursery due to its greater susceptibility to *Phytophthora* root rot, so its availability is somewhat limited unless trees are special ordered on this rootstock.

Based on the results thus far, *C. macrophylla* appears to be a superior rootstock for lemons in Arizona; although the possibility exists that it may decline sooner than 'Rough Lemon' or *C. volkameriana*. However, it is probably not a good idea to plant all ones acreage on only one rootstock, thus either *C. volkameriana* or 'Rough Lemon' would be a good complementary rootstock as well.

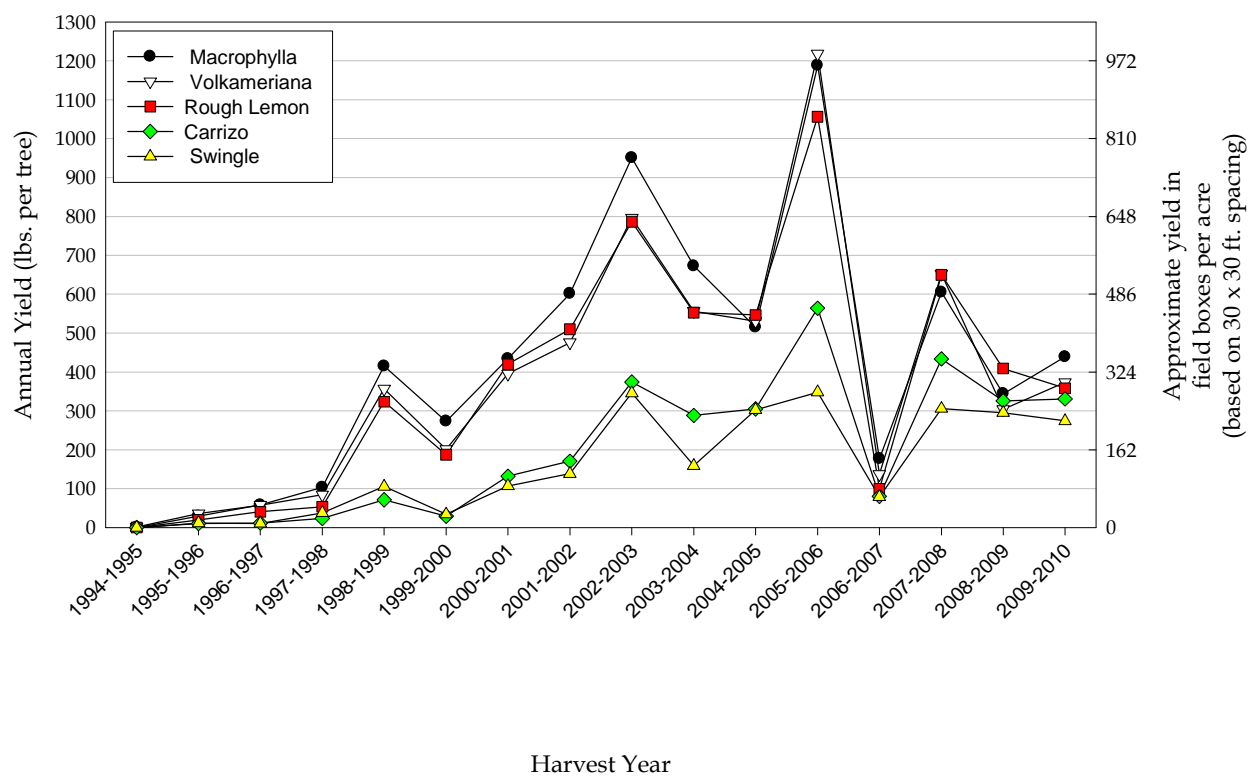


Figure 1. 1994 – 2010 'Limoneira 8A Lisbon' lemon yields on five rootstocks.

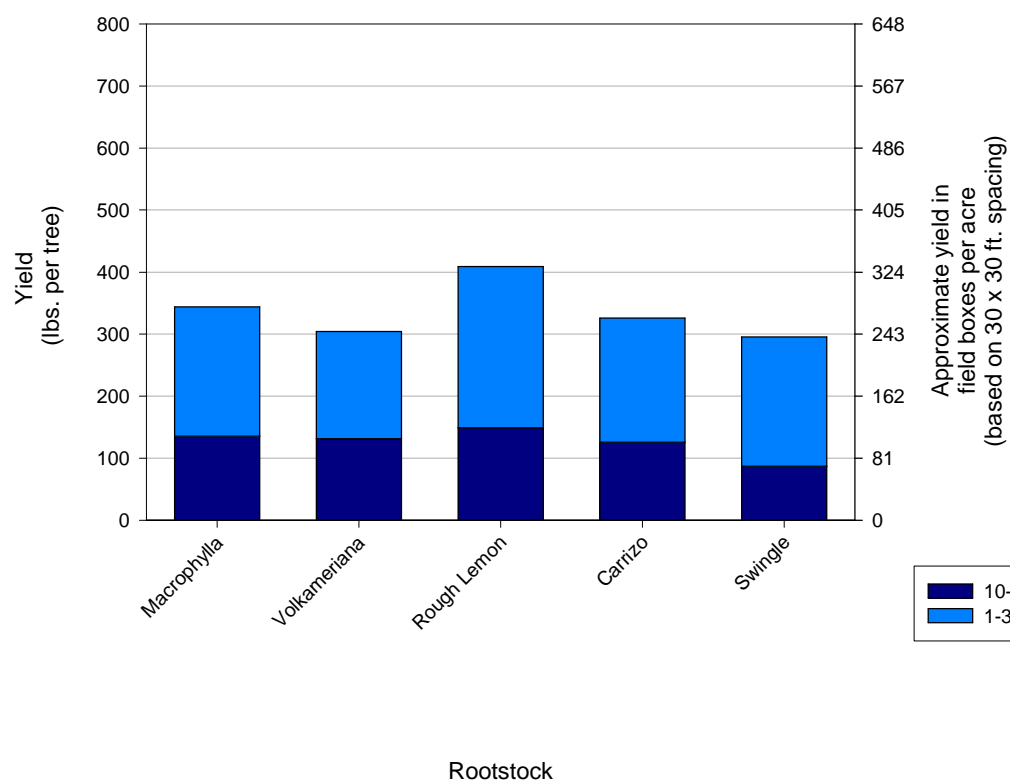


Figure 2. 2008-09 yield of 'Limoneira 8A Lisbon' lemon yields on five rootstocks. Mean separations by Duncan's multiple range test, 5% level.

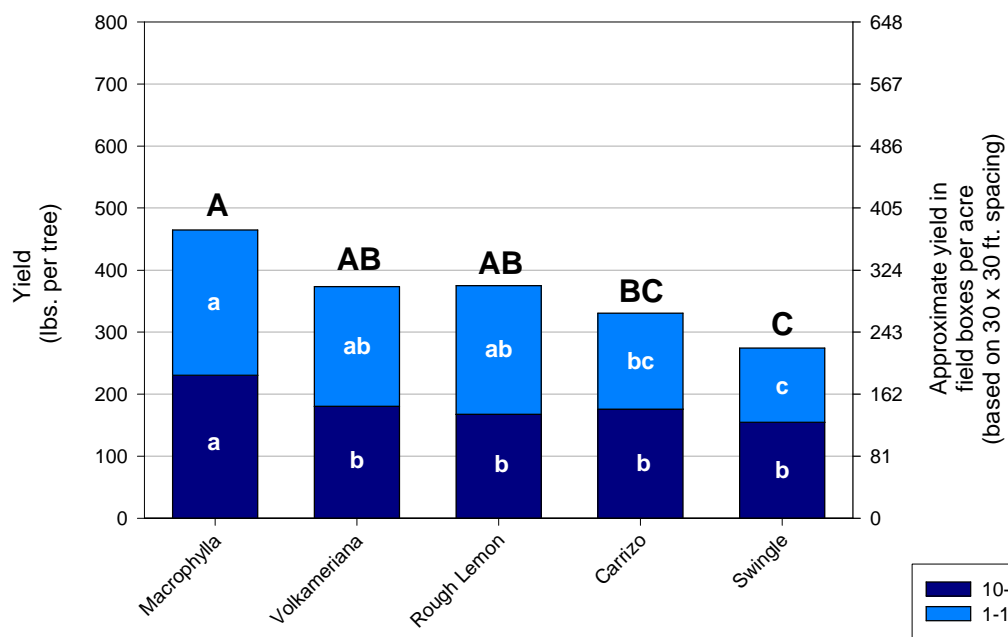


Figure 3. 2009-10 yield of 'Limoneira 8A Lisbon' lemon yields on five rootstocks. Mean separations by Duncan's multiple range test, 5% level.

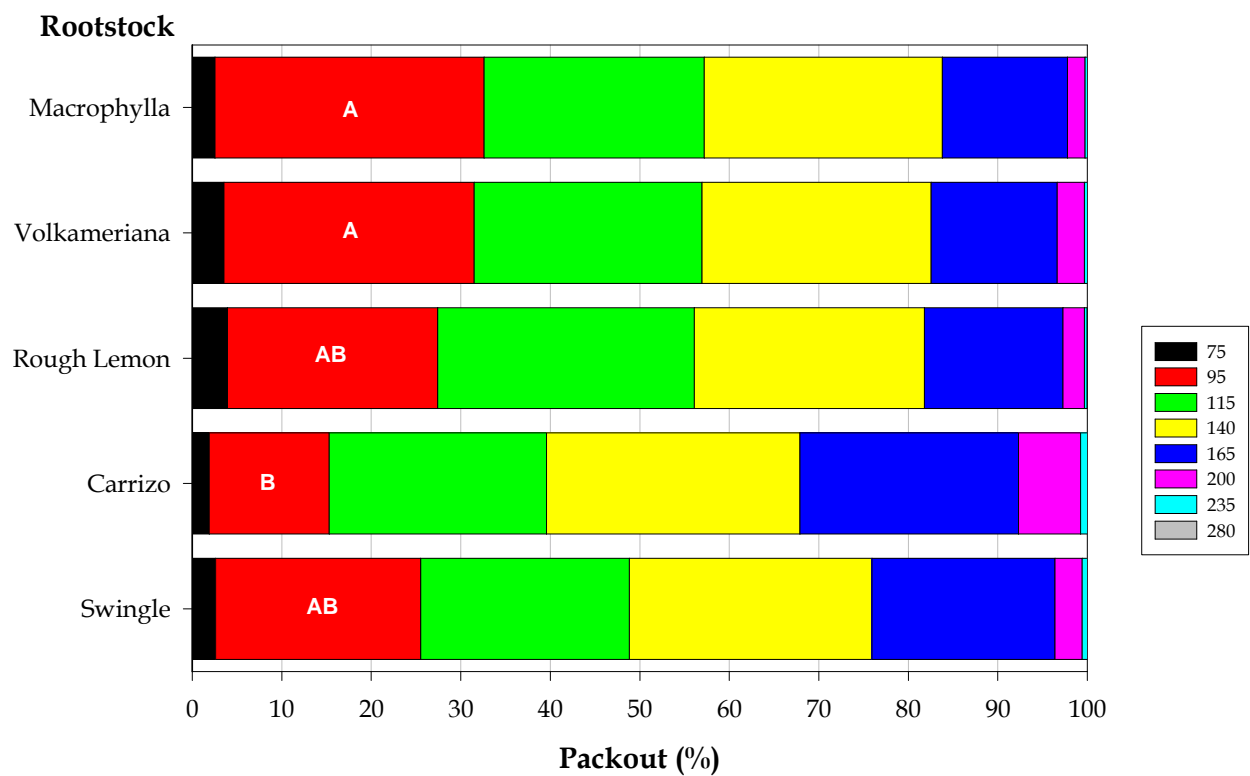


Figure 4. Packout of 'Limoneira 8A Lisbon' lemons on five rootstocks from the October 14, 2008 harvest. Means separation within fruit sizes by Duncan's multiple range test, 5% level. Bars of the same color are significantly different if the letters within them are different. Bars of different colors cannot be compared statistically.

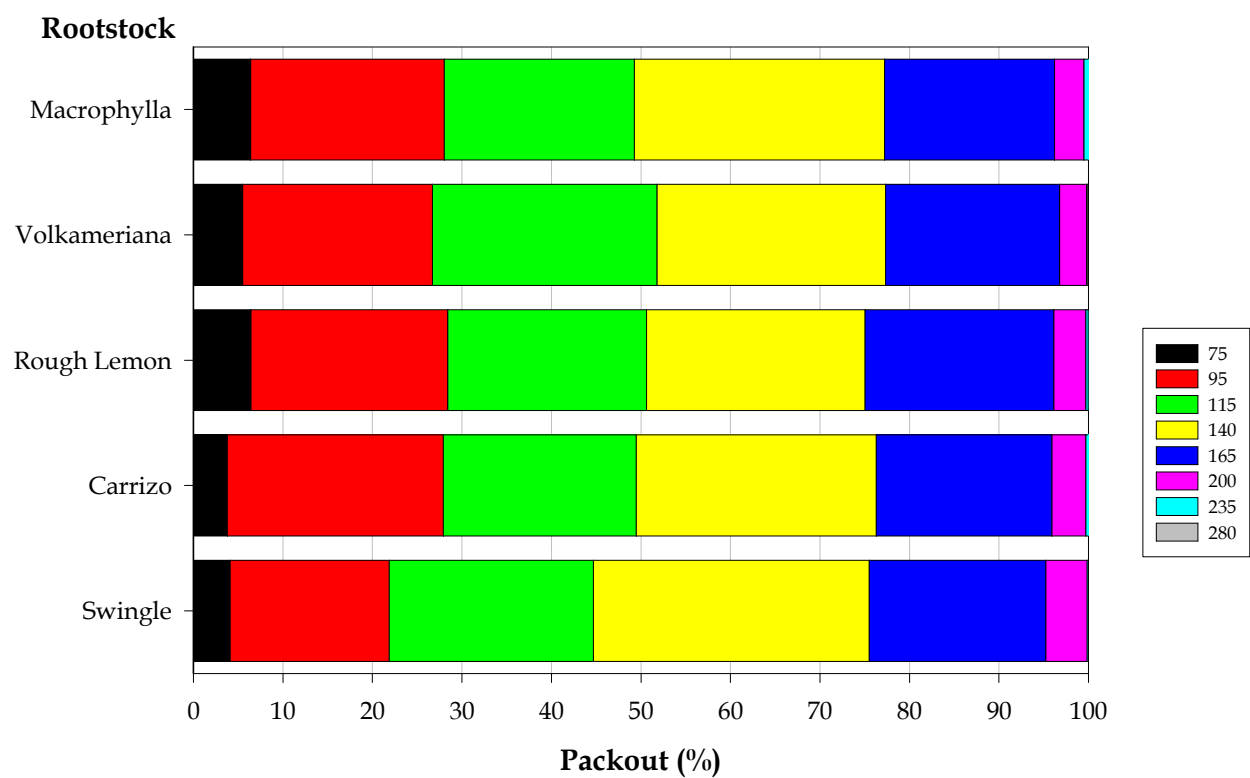


Figure 5. Packout of 'Limoneira 8A Lisbon' lemons on five rootstocks from the October 19, 2009 harvest. .

Table 1. 2007-08 harvest exterior fruit quality, shape and color of lemons on four different rootstocks

Rootstock	9-27-07 Harvest					11-28-07 Harvest				
	Fancy (%)	Choice (%)	Juice (%)	Shape ^y	Color ^x	Fancy (%)	Choice (%)	Juice (%)	Shape	Color
<i>C. macrophylla</i>	43.96 b ^z	45.86 a	10.18 a	0.744 b	0.794 a	81.83 a	10.88 ab	7.29 a	0.761 b	1.017 ab
<i>C. volkameriana</i>	49.57 b	42.73 a	7.70 ab	0.771 a	0.793 a	86.19 a	8.65 b	5.16 ab	0.781 a	1.006 b
Rough Lemon	52.38 ab	39.80 ab	7.82 ab	0.762 ab	0.800 a	84.07 a	9.74 ab	6.18 ab	0.778 a	1.016 ab
Carrizo Citrange	62.23 a	33.70 b	4.07 b	0.759 ab	0.789 a	84.46 a	12.30 a	3.24 b	0.771 ab	1.037 a
Swingle Citrumelo	54.56 ab	38.26 ab	7.17 ab	0.756 ab	0.784 a	86.52 a	8.44 b	5.05 ab	0.771 ab	1.029 a

^z Means separation in columns by Duncan's Multiple Range Test, 5% level.

^y A value of 1.00 signifies a completely round fruit.

^x Signifies the red to green intensity ratio of the fruit. A greater value signifies more orange or red color.